The Human Systems Integration Division advances design and operations of complex aerospace systems through analysis, experimentation, and modeling of human performance and human-automation interaction to make dramatic improvements in safety, efficiency, and mission success.

Human-Machine Interaction

The Human-Machine Interaction Group contributes to the development of measurably better NASA software through careful application of Human-Computer Interaction (HCI) methods. The group follows an iterative process that consists of user research, interaction design, software development, and usability evaluation. This approach enables us to deploy and integrate mission software, with the right functionality and user interfaces, for scientists and engineers on some of NASA's largest programs.

Human Performance

The Human Performance Group performs research and technology development to enhance health, productivity, and safety in aerospace environments. The group develops advanced interfaces, models of human performance, tools for monitoring performance, and countermeasures to mitigate performance deficits. The group includes labs that focus on advanced multi-modal interfaces, auditory displays, human cognition, performance modeling, psychophysiology, telerobotics, virtual environments, vision science, and visuomotor control.

Integration and Training

The Integration and Training Group is committed to improving the efficiency and safety of the Air Transportation System, with emphasis on mid-term and long-term requirements. This group develops and evaluates methods drawn from Human Factors and related disciplines for the integration of humans as intrinsic to the Air Transportation System as a whole. The group includes full-mission laboratories associated with air traffic management, flight deck and air-ground procedures, and surface operations. It also includes labs dedicated to fatigue countermeasures, training, and distributed team decision-making.

Design: Phil So
Printed: August 2014

http://hsi.arc.nasa.gov

NASA Ames Research Center
Human Systems Integration Division
Mail Stop 262-1
Moffett Field, CA 94035
http://hsi.arc.nasa.gov

Human Systems Integration Division | 2015

Advancing Design and Operations of Complex Aerospace Systems

Human Systems Integration Division
Ames Research Center, Silicon Valley, CA
National Aeronautics and Space Administration (NASA)

Advancing Design and Operations of Complex Aerospace Systems

People are the most critical element in system safety, reliability, and performance. Their creativity, adaptability, and problem-solving capabilities are key to resilient operations across the gamut of aerospace applications. Advances in computing power and communications, increased automation and access to distributed information resources for collaboration, monitoring and control, all contribute to new challenges for humans as critical decision-makers in complex systems.

Dr. Alonso Vera

In aviation, people are the backbone of a national aviation system that is straining to meet growing consumer demands. In space, long-duration missions and reusable launch vehicles will increase the requirement for safe and effective human performance in the harsh environments surrounding our planet. The design must address the need for safe, efficient and cost-effective operations, maintenance and training, both in flight and on the ground.

The Human Systems Integration Division is creating and applying a new understanding of how individuals and teams assimilate and act on information in pursuit of goals critical to the success of NASA missions.

Strategic Goals

- To advance our fundamental understanding of how people process information, make decisions, and collaborate with human and machine systems.
- To enhance aviation safety and performance by designing human-centered automation and interfaces, decision support tools, training, and team and organizational practices. The Human Systems Integration Division is creating a new understanding of how individuals and teams assimilate and act on information in pursuit of goals critical to mission success.
- To extend human capabilities in space by advancing our knowledge of human performance during space missions and developing tools, technologies, and countermeasures for safe and effective space operations.

Human-Machine Interaction

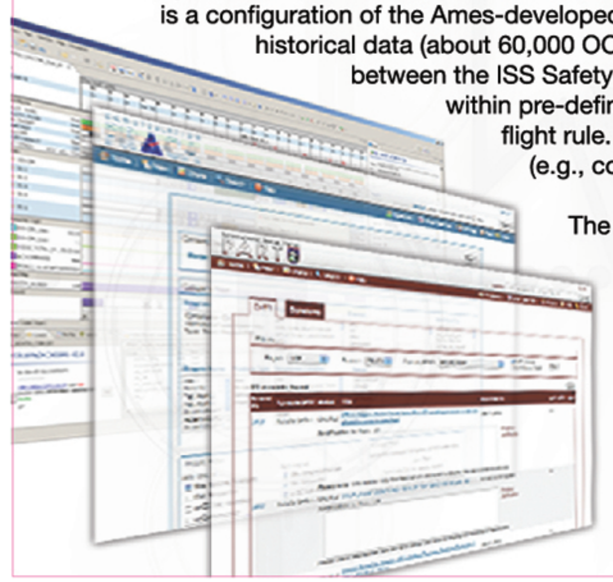
Three Ames Software Planning Tools Working in Unison at ISS Mission Control

Since 2008, the Human-Computer Interaction group, in collaboration with the Ensemble team, has designed, developed, and deployed three planning and scheduling software tools that are currently on Mission Control consoles playing key roles supporting International Space Station (ISS) operations. The three tools are the Score Planning Tool, the ADCO Planning Exchange Tool (APEX), and the Power Planning and Analysis Tool (PLATO), which allow for planning crew activity operations, attitude determination, and control, and solar array articulation, power, and thermal control respectively. During the 2013 docking of HTV-4, a Japanese resupply spacecraft, the three tools worked in unison to support these complex operations, which require coordination between all disciplines in Mission Control. This mission critical event requires ISS to be at a specific attitude, which in turn changes the amount of solar power generation possible, all happening simultaneously as crew and ground support need to grapple and berth the spacecraft. Ops Planners use Score to create and modify mission plans containing all crew and ground activities on ISS. Score helps Ops Planners create and make changes to these plans by automatically validating operational requirements, calculating mission critical resources, and processing real-time plan changes. The plans created in Score are distributed to the other disciplines in Mission Control to coordinate operations. APEX is the primary planning tool for the Attitude Determination and Control Officers to control attitude and thruster reconfiguration events, as well as coordinating attitude changes with Russian partners. PLATO is used by the Power Resource Officer to support the Station Power, Articulation, and Thermal Control flight controllers. PLATO integrates various power analysis engines, calculating solar power availability versus consumption and ensuring that all hardware rules are met. Each of these three planning and scheduling tools plays an essential role in planning and completing all complex, coordinated events for ISS Mission Control.

Point of Contact: Dr. Jessica Marquez, jessica.j.marquez@nasa.gov

Mission Assurance Systems (MAS) Deployment

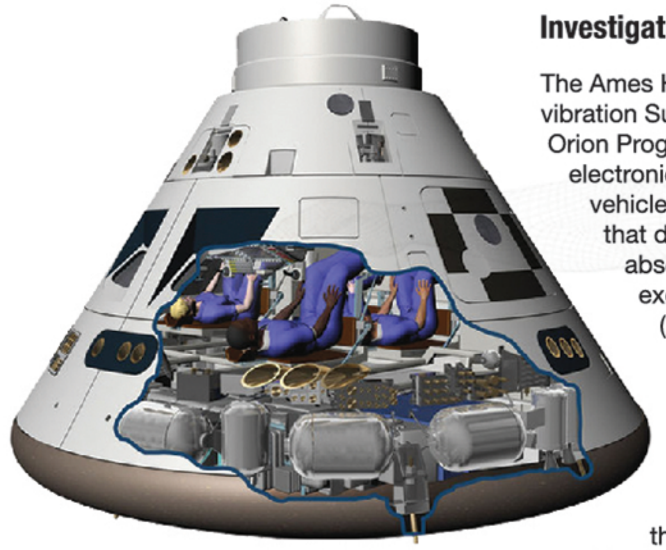
The Human-Computer Interaction (HCI) group within the Human Systems Integration Division deployed a new system for Operational Control Agreement Documents (OCADs) for the International Space Station and Mission Operations Directorate (MOD). The system is a configuration of the Ames-developed Mission Assurance Systems (MAS) Open Source platform and contains all the historical data (about 60,000 OCADs) migrated as part of the deployment (May 2014). OCADs represent an agreement between the ISS Safety engineers and MOD that a specific Hazard will be controlled by operating the vehicle within pre-defined parameters. Once an OCAD is approved, it is implemented as a procedure or flight rule. Benefits of the new system include improved permissions for proprietary data (e.g., commercial crew) and the built-in capability to integrate with external systems.



The ISS Program has approved an integration between ISS Hazards, another MAS system, and the new OCAD system. The integration will improve tracking between Hazard and OCADs. Users will be able to automatically create new OCADs from Hazards (without copying data), link related records, see the status of related records, and run searches, which currently require significant manual work. The broader ISS vision is to link related data sets that enable engineers to efficiently address risk posture questions such as, “Does a proposed change to a procedure still control the associated hazard?” The OCAD system is the fourth MAS-based system deployed for the ISS program.

Point of Contact: Irene Tollinger, irene.tollinger@nasa.gov

Human Performance



Investigation of Lateral Whole-Body Vibration Impacts on Display Readability

The Ames Human Vibration Laboratory, led by Dr. Bernard Adelstein, NASA's human vibration Subject Matter Expert, was asked by the Space Launch System (SLS) and Orion Programs to assess the impact of lateral vibration on astronaut ability to read electronic flight displays. The Programs' concern arose because the Orion crew vehicle could undergo 12-Hz lateral vibration in response to the thrust oscillation that develops in the SLS' solid rocket boosters during launch. Due to the absence of relevant prior data, the Human Vibration Laboratory designed and executed a rapid-response study, funded by the Human Research Program (HRP), in order to provide a quantitative understanding to SLS, Orion and Astronaut Office stakeholders of the effects of lateral vibration on crew visual performance. The study demonstrated that the 15 study participants' (12 general population plus 3 astronauts) reading task error rates and response times were not degraded by 12-Hz lateral vibration up to the maximum amplitude tested, ± 0.7 g. This lack of impact has enabled SLS and Orion to relax existing programmatic requirements, thereby raising the maximum permissible thrust-oscillation driven lateral vibration up to this level, i.e., 0.7 g-peak (0.5 g-rms).

Point of Contact: Dr. Bernard Adelstein, bernard.d.adelstein@nasa.gov

Patent Issued for Visual Motion Blur

In 2014, the US Patent and Trademark Office (USPTO) issued US Patent #8,675,922 titled "Visible Motion Blur" to NASA and inventors Dr. Andrew Watson and Dr. Albert Ahumada of the Human Systems Integration Division at Ames Research Center. The authors' decades of vision research enabled them to develop an innovative method to calculate the perceptibility of the blur of a moving object presented on an electronic display device. The patent describes technology that enables the estimation of the visibility of image blur of moving objects presented on electronic displays ranging from cell phones to LCD televisions. Motion blur can be significant artifact of all display technologies. It arises from visual and neural processing of images presented on displays which present individual frames that persist for significant fractions of a frame duration. This technology will assist in development, testing, and certification of future display devices.

Point of Contact: Dr. Andrew Watson, andrew.b.watson@nasa.gov

Integration and Training

Flight Deck Display Research Laboratory Conducts Single Pilot Operations Study

The Flight Deck Display Research Laboratory (FDDRL), in collaboration with researchers at NASA Langley Research Center, is conducting research on the feasibility of moving from two pilot crews to single pilot operation (SPO) for commercial transport aircraft. As part of this research, the FDDRL conducted a simulation study, funded by the Airspace Systems Program, examining ground-supp orted single pilot operations in the Crew-Vehicle Systems Research Facility (CVSRF). This study examined very high workload, off-nominal, and emergency scenarios in which professional air transport pilots, departing from or arriving at Denver International Airport, had to select and then divert to other airports. Nineteen two-person commercial crews flew the Advanced Concepts Flight Simulator in the CVSRF in each of three conditions: 1) together on the flight deck as they do today (baseline condition), 2) one pilot on the flight deck and a "ground dispatch pilot" (GDP) at a first-generation ground station that provided basic displays, controls, and trajectory management tools, and 3) one pilot on the flight deck and a GDP at a ground station that provided not only these displays, controls, and trajectory management tools, but also a variety of additional collaboration tools and displays (such as Crew Resource Management indicators) to aid in air-ground collaboration. While more challenging than two pilots on the flight deck, ground-supported SPO performance was safe and feasible for these demanding scenarios, with no impact on divert decision times or divert choices. Additionally, the collaboration tools resulted in increased CRM and decision-making communications, and positive ratings by the onboard and ground dispatch pilots.

Point of Contact: Dr. Walter Johnson, walter.johnson@nasa.gov

Human-in-the-Loop Simulation Investigates NextGen Future Operations for High-Complexity Airspace

Researchers with the Airspace Operations Laboratory conducted a human-in-the-loop simulation to develop integrated NextGen solutions for the National Airspace System. A problem scenario that included high-volume traffic flows inbound to Newark International Airport, through seven Washington Center and New York TRACON sectors, was used to drive development of integrated concepts tailored to address the specific challenges associated with this airspace. Retired Subject Matter Experts from each of these FAA facilities worked with the NASA researchers to test and refine operational concepts for the NextGen Mid-Term and Far-Term. Each of these two NextGen Future Environments consisted of an integrated set of automation tools and procedures for time-based metering, conflict detection and resolution, optimized descents, efficient trajectory and flow planning, air-ground and ground-ground communications, and traffic management appropriate to their respective time frame. Results from the simulation showed a potential to safely increase Newark Airport's clear-weather arrival rate by 30% (from 52 to 67 arrivals per hour) while flying low-power descents that reduce the noise and emissions impact on the local community. A follow-up study will explore using a similar approach to improve arrival and departure throughput at LaGuardia Airport.

Point of Contact: Nancy Smith, nancy.m.smith-1@nasa.gov